Chapter 8
Cloud and IoMT-Based Big Data Analytics System During COVID-19 Pandemic

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8.1 Introduction

The occurrence of coronavirus (COVID-19) is greater than that of respiratory infections syndrome (SARS) that took place in 2003. As of 12 August 2020, the reported cases are more than 73,435 deaths and more than 2000 deaths worldwide, and both COVID-19 and SARS are distributed across regions, infecting living beings [1, 2]. By contrast, in 2003, SARS claimed 774 lives, but in the shortest time, COVID-19 claimed more than that. But the significant difference among them is that since 17 years of SARS, other new power tools have emerged, which could be used as an instrument in fighting this virus and keeping it within reasonable limits. Internet of Things (IoT), wearable body sensor (WBS), and Machine Learning (ML) are examples of such tools. Recently, these methods have caused a paradigm shift in the healthcare sector, and the applicability of these methods in the COVID-19 outbreak might yield profit especially in predicting, monitoring, and diagnosing and treatment of patients during the outbreak. Their application in COVID-19 pandemic can expedite the diagnoses and monitoring of COVID-19 and can minimize the burden of these processes.

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The outbreak of Coronavirus (COVID-19) infection at Wuhan, China, in December 2019 is spreading widely across the world. Globally, as stated to the WHO as of 1 September 2020, there were 25,328,298 identified COVID-19 cases, with 850,926 global deaths at 10:50 am CEST in 213 countries/regions [3]. Since it is a new pandemic, real drug strategies were not anticipated to be ready for any time soon; meanwhile, community-based control methods such as stay home policy and lock-outs were effectively applied by pretentious nations to squash the pandemic curve affecting an estimated 3 billion people worldwide [4, 5].

COVID-19 is exceptionally infectious and can spread complications before and after the onset. Monitoring and lockdown have to encompass anyone with symptoms and properly isolate persons who have been infected from those who are not, to allow adequate containment. Patients carrying the virus could either be symptomless (e.g., fever, sore throat, and sneezing) or have severe clinical signs (e.g., pneumonia, respiratory failure, and eventually death) [6, 7]. The transmittable SARS-CoV-2 condition is called "coronavirus disease" (COVID-19) [1, 5]. Gratitude to the recent developments in analytical practices including information and communication technologies (ICTs), machine learning (ML), and big data will aid manage the immense, unparalleled volume of data generated from patient monitoring, real-time tracking of disease outbreaks, now-casting/predicting patterns, daily situation briefings, and public updates [8].

Health professionals are in desperate need of technology for decision-making to tackle this epidemic and allow them to get timely feedback in real time to prevent its transmission. AI works to simulate the human intellect thoughtfully. This may as well play a crucial responsible in interpreting and recommending the creation of a COVID-19 vaccine. This result-driven engineering is employed to scan better, evaluate, forecast, and monitor current clinicians and patients expected to be in future. The relevant technologies relate to the monitoring of verified, recovered, and death cases.

In remote detection, prediction, surveillance, recovery, and therapy, the Internet of Things (IoT)-based system is very useful and paramount part in which telemedicine has recently been broadly applied. With interest in designing smart technologies, such as healthcare tracking systems, medical diagnosis, prediction and treatment systems, and smart healthcare, IoT has recently been implemented in the medical sector. Data are obtained from remote medical devices, such as CT machines and MRI machines, wearable sensors, and then distributed and reconfigured locally in three dimensions during the telemedicine process. The Internet of Medical Stuff (IoMT) provides a forum for sensors and machines to connect inside a smart world and to exchange knowledge across medical channels easily.

This pandemic has activated anxiety on public health surveillance and has generated an extraordinary need for remote patient monitoring. Internet of Medical Things (IoMT) smart healthcare is gaining impact to manage COVID-19 in this era of innovative digital expertise. The popularity of wearable devices provides a new perspective for the precaution of infectious diseases. Wearable devices are one solution that provides a practical option for the omnipresent, reliable, and accessible tracking of patients in chronic, relieve environments. Hence, wearable and implantable body area network structures are handy for the unceasing intensive care of the patient during COVID-19.

By benefiting from the full possibilities provided by Internet technology, the latest adaptation to numerous wireless technology places IoMT-based system as the next innovative technology. There is an immense growth in the volume of data produced by sensors, smartphones, social media, healthcare apps, temperature sensors, and numerous other technological applications and interactive resources that regularly produce vast volumes of organized, unstructured, or semi-structured data. The methods of searching for a database, mining, and reviewing data devoted to optimizing market efficiency are used in big data analytics. Big data analytics is the method by which massive data sets representing several categories of data are analyzed. Voluminous volumes of data have been produced as the miniaturization of IoMT devices has increased over the last decade. However, without analytical capacity, such data are not useful. Numerous solutions for big data, IoMT, and analytics have allowed individuals to gain useful insights into the comprehensive data produced by IoMT devices. Ses ideas are still in their infancy, however, and the domain needs a detailed investigation.

The data science analysis using big data analytics is newly evolving, intending to empower healthcare systems to connect, harness information, and convert it to usable knowledge and preferably personalized clinical decision-making. Utilizing and application of IoT-WBS-based system in the field of infectious diseases have implemented a range of improvements in the modeling of knowledge generation. Big data can be interpreted, stored, and collected in healthcare through the continually emerging field of these models, thereby allowing the understanding, rationalization, and use of data for various reasons. Therefore, this chapter proposes a framework for Cloud-IoMT-based big data analytics to guaranteeing better expansion and research against COVID-19. The hope of using the framework in COVID-19 will have a significant impact on the quality of outbreak diagnosis, prediction, and treatment. It can deliver quality care to patients across socioeconomic and geographic boundaries.

The organization of this chapter is as follows: Section 8.2 discusses the importance of IoMT-based system during COVID-19 pandemic. Section 8.3 presents the applicability and the usefulness of wearable body sensor networks during COVID-19. Section 8.4 presents the CI-WBSN framework for monitoring the elderly patient during the COVID-19 outbreak. Section 8.5 offers a practical case of CI-WBSN for watching older people. Section 8.6 presents result, discussion, and future research direction. Finally, Section 8.7 concludes this chapter and looks at the future direction of using IoMT-based system for battling infectious diseases.

8.2 Application of the Internet of Medical During COVID-19 Pandemic

IoT-based systems have provided various types of sensors and devices such as blood glucose tracking system that can be used in smart healthcare system for monitoring of several health-rated diseases [9, 10]. During this period of COVID-19 outbreak, the used of hybrid sensors with actuators as well as mobile equipment will really provide real-time monitoring and diagnosis of patient effectively and accurately globally [7, 11]. The IoMT-based system is a version of IoT-based systems in the healthcare systems using smart devices to capture data from the patient, and consequently process by the inbuilt Machine Learning algorithms for proper decision-making by medical professionals. Thus, this system can be used for proper decision-making by the government agency and medical experts during infectious disease outbreak [12, 13]. There are over 3.7 million smart devices that are linked together by various wireless technologies that can be used for various purposes in smart healthcare systems [14].

There are various types of commercial cloud that can be used as cloud infrastructure such as Amazon Web Services and Google Cloud Computing among other custom web services for data storage. Furthermore, IoMT services can be used for remote monitoring of patient for short- or long-term illness both in urban or rural areas globally. The system can be used by an elderly patient to diagnose, and monitor their health status using wearable devices without necessarily visiting the clinic or hospital. The health records they have obtained can be submitted to their doctor.

This could be shown that the IoMT system operates with a massive deployment of resources for detecting and controlling. The IoMT is regarded to be the large-scale application of machine type communication (MTC) equipment which performs sensing actuation activities through nominal human intervention. The number of Internet-connected objects is estimated to surpass the number of persons in the society. That is because IoT is focused on the reasonableness of networking specific physical gadgets via the connected networks, for instance, the majority of health gadgets linked to the Internet is growing exponentially everyday [15]. Besides, healthcare services are considered the largest target market for IoMT, with the pulse rate tracking being identified as the most significant benefit [16]. Use essential devices such as glucose levels pulse rate tracking, the IoMT systems used to implement urgent warning systems, and remote medical surveillance systems accessing data into more advanced technologies.

Such specific instruments, as a typical example [17], can track particular devices used by Bpacemakers. It would be advantageous to build such a program mainly for the aged, and those with serious illness. Health records will be sent to the health service via smartphone for screening, assessment, and interpretation. These systems need to ensure current efficiency, to be effective and efficient operate efficiently, to track the condition of the patient automatically, and to respond appropriately safely [18]. Therefore, these programs must gain patient trust in the protection of their patients' personal information. The devices, mobile, smart-home network, public contact networks, and hospitals network were exposed to numerous security concerns most of the time; the critical explanation was the weaknesses derived from wireless technology.

In these difficult COVID-19 period, older patients face many severe and critical problems [19]. The goal of IoMT is to link individuals to healthcare facilities to track and regulate vital signs of the human body using connectivity infrastructure [20]. Telemedicine is becoming common in remote locations where, due to multiple reasons, accessibility to a professional physician is minimal [21].

Heart rate, electrocardiography, diabetes, and vital physiological signs, for example, can all be tracked remotely without the intervention of clinicians. Sensors and actuators are examples of devices that can accept data from a patient and send it to the cloud through a local gateway. The doctor reviews the data using any smartphone or laptop device that has been given to them, and then informs the patient or medical staff who is caring for them about the study [22]. Figure 8.1 describes the various methods and techniques used by IoMT to support the patient during COVID-19.

IoMT also helps physicians and healthcare practitioners to offer medical services to patients by providing them with solutions in crucial and rural locations [23, 24]. This approach also decreases the overall type of discomfort and increases the productivity of, among others, the doctors, workers, and nurses. It reduces unnecessary hospital admissions and the overall burden on healthcare organizations by linking older patients directly with their physicians and thus enabling health information to be transferred via a protected site.

The IoMT is the expanded health-specific edition of the Internet of Things (IoT) [12]. Introduced to the present situation can be used to build a social forum to help individuals access appropriate treatment at home and to develop a robust repository

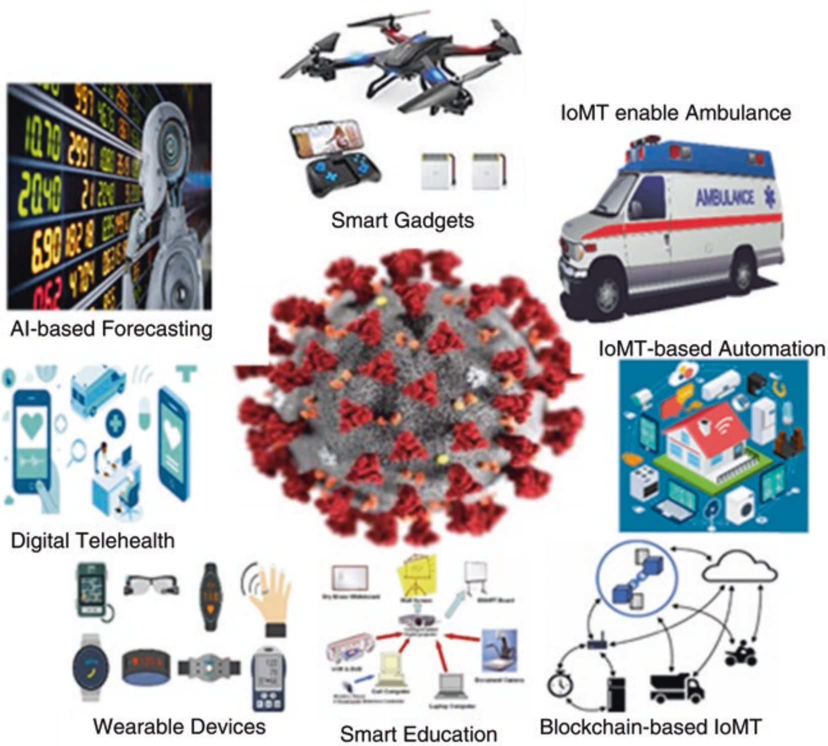

Fig. 8.1 Prospective applications of IoT to combat COVID-19

on disease control for government and healthcare organizations by diagnosis and healthcare devices could be obtained for persons with minor symptoms (preventive disguises, thermometers, medicines, personalized COVID-19 infection diagnosis, and control kits). Patients were able to upload their overall health to the IoMT (clinical data storage) site online regularly and exchange their relevant data to area hospitals, the Center for Disease Control (CDC), and state and local health offices.

Now the global epidemic COVID-19 has become the primary hub of scientific research. The new digital technologies will act as a perfect solution to this worldwide crisis. IoMT can address the problem of detecting, surveillance, mapping contacts, and controlling this viral infection [5, 25].

Healthcare facilities could then provide electronic health evaluations regarding the health status of each individual. If appropriate, the administration (the CDC and state and municipal health offices) could assign resources and designate containment centers (guesthouses or regional quarantine establishments). Using the IoMT system, humans could supervise their disease activity automatically and receive appropriate healthcare needs without transmitting the disease to someone else. It will minimize global medical expenses, alleviate the pressures of the shortage of healthcare equipment, and provide a centralized database allowing the government to effectively track disease transmission, distribute supplies, and enforce emergency strategies.

The currently daunting COVID-19 disease outbreak circumstance is convincing for, among others, medical professionals, nurses, and medical employees. IoMT could be used to offer essential and relevant, positive, and motivating treatment services to its patients. This chapter provides the possibility of providing medical services to older patients via the IoMT program during the COVID-19 disease outbreak. During this epidemic, older patients also face many challenges, such as attending treatment facilities, buying medication, monitoring, and reporting. [26]. Through the IoMT strategy, these conflicts can be addressed more conveniently and easier. This also benefits the older patients who live or are trapped in some distant area where medical services cannot otherwise be given promptly and satisfactorily.

8.3 The Use of Wearable Body Sensors Network for Combating COVID-19 Outbreak

Technological advances of low-cost, insightful, compact, and insubstantial medical sensor networks have been accepted for positioning themselves ideally on the human body using wearable devices and sensors [27]. This helps in creating a system for long-term tracking of various major chronic physical diseases, delivering real-time input to users and medical workers, aiming to revolutionize health monitoring [27]. The WSN technologies are regarded as one of the leading scientific fields for enhancing the quality of care in the computer science and healthcare applications sectors [28].

Utilizing digital innovations such as wearable sensor networks and the IoMT movement are bringing improvement in COVID-19-guided surveillance of older patients [7]. Together with the IoMT-powered mobile devices, the processing strategies are supporting evolving and encouraging real-time healthcare systems in isolated areas. Meanwhile, electronic and wireless communication technologies have thoroughly changed the medical world by pressing smart and tiny sensors that can be used on or inside the human body.

The implementation of these sensing devices with evolving health technology is the fundamental change toward highly sustainable, intelligent, and omnipresent medical cities and homes for the elderly in isolated areas [29]. Body sensor networks (BSNs) is an improvisatory and prospective candidate for stepping up medical innovation and education to improve the healthcare platform further. Wearable sensor networks (WSNs) have revolutionized healthcare sectors with the introduction of various implantable and wearable sensors and devices, and has been used in several fields such as transportation, emergency services, healthcare, among others. The use of AI with wireless sensors with simulation has created an open research in the area of intelligent systems. This has resulted in the creation of interdisciplinary paradigm in ambient intelligence to resolve various healthcare challenges in our daily life [30].

The use of WSNs in smart healthcare system has created a wide range of applications and it can be used to solve various healthcare challenges. Thanks to the integration of single-chip sensors with mass production of WSN, the smart healthcare has really changed the healthcare industry with radio interfaces and computer chips [31]. The system can be used for various purposes like in emergency services, surveillances, agricultural practices, and in healthcare monitoring services. The most useful application of WSN during this pandemic is the tracking and monitoring of COVID-19 patients in real time globally [32–34].

The popular sensor nodes designed and placed in specified locations are limited when compared with the WSNs that can be installed with an ad hoc, thus making them robust, fault-tolerant, and cover larger area [35, 36]. This really helps in monitoring and tracking of patient in real time and remotely without any intervention of any kind. As a result, these strategies will alleviate burden and stress on healthcare personnel, resulting in the reduction of medical errors, reduce healthcare cost, and bring about patient satisfaction with an increase in medical professional effectiveness [37, 38].

The challenges and inaccuracies in the use of IoMT-based system are as a result of lack of reliable and detailed information at the right time because of the inaccurate diagnosis and prescription problems [38, 39]. The risk of death and inaccurate diagnosis would have been reduced if adequate precautions are offered to patients at the right time [40]. Medical experts need adequate information about any patient in order to ensure safety and thereby save lives at the right time and in real-time basis. As a result, patients with life-threatening diseases such as diabetes, heart disease, and high blood pressure need a healthy and low transmission latency. Sensor networks can be strategically placed on the human body to create a cluster WBAN, thus used to capture and collect disease signs and symptoms from patients [41, 42].

Also, as shown in Fig. 8.2, BSNs are made up of a large number of different biomedical sensors, and these sensing nodes wirelessly track and communicate abnormal changes in a patient's vital sign or physiological signals such as temperature, pulse, and blood pressure. Wearable sensors can collect and record data on one's diagnosable disorder and moving responses in real time.

This has really helped and changed the outlook of smart healthcare technology in recent years with introduction of various devices and sensors that can be embedded and implanted in human body. As applied to biomedical technology, this is known as biomedical sensor wireless networks (BWBSNs) [43, 44]. The WBSN allows for the embedding of low-power, remotely controlled smart ubiquitous sensor nodes to track body systems and their surroundings. Every node can detect, track, and send data to the Super Sensor. During the COVID-19 pandemic, selected sensors used in IoT for information collection and monitoring are depicted in Fig. 8.2.

Fig. 8.2 Selected worthwhile sensor devices for collection data on IoT during COVID-19

8.4 Big Data Analytics Opportunities in IoMT-Based Platform

Big data analytics is quickly emerging as a crucial initiative for IoMT. One of the utmost influential characteristics of IoMT is its study of related stuff knowledge [45]. Big data analytics in IoMT requires the giving out of huge capacities of data and the storage of data in different storage technologies. Since big formless data are assembled unswervingly from web-aided possessions, broad data implementation will require lightning-fast analytics with extensive inquiries to enable establishments to access quick intuitions, make speedy verdicts, and relate with persons and other gadgets. Recognizing and motivating gadgets interconnect with the opportunity to exchange knowledge crosswise networks across a cohesive infrastructure and build a shared functioning image to allow creative applications [45].

In the healthcare industry, voluminous volumes of data were generated during the last few years. This rapid growth in data output has, however, produced difficulties in extracting useful knowledge from extensive medical data that can aid pandemic forecast and cure numerous sicknesses [46]. Data analytics can help healthcare professionals examine vast volumes of medical data and learn about a clinical history (with the understanding of private clinicians). Insurance firms might as well employ data mining for policymaking. Healthcare practitioners can also diagnose dangerous illnesses at an early stage and thereby avoid the loss of life [46]. The IoMT-based program created a smart healthcare framework contributing to the diagnosis of epidemics, treatments, and illness.

Smart health tracking apps have evolved exponentially in recent years. These devices generate massive quantities of data. Therefore, adding data processing to data obtained from baby monitoring, electrocardiograms, temperature sensors, or blood glucose level monitoring will assist medical professionals inaccurately determine patient clinical conditions. Data analytics allow healthcare practitioners to detect dangerous diseases at their first steps to aid rescue being. Data analytics increases the medical excellence of treatment, including ensuring patient health. Furthermore, the background of doctors can be checked by looking at the past of patient care, which can boost client loyalty, acquisition, and retention (Fig. 8.3).

Enhanced competency: The criteria for handling and storing data from progressive analytics utilization have hindered their implementation in numerous regions. Such obstacles are thus starting to collapse due to IoT [46]. Big data technology, for instance, Hadoop and cloud-based mining tools, provide substantial cost-cutting benefits relative to conventional mining techniques. Besides, traditional analytical methods involve data in a positive form, which is hard to do while employing IoMT-based data. Using existing big data solutions that develop around less-cost group infrastructure, though, will help boost the analytics capabilities and reduce computing costs.

Independence from data silos: The initiation of IoT, including empowering technology, for instance, cloud computing has enabled data storage towers to be replaced

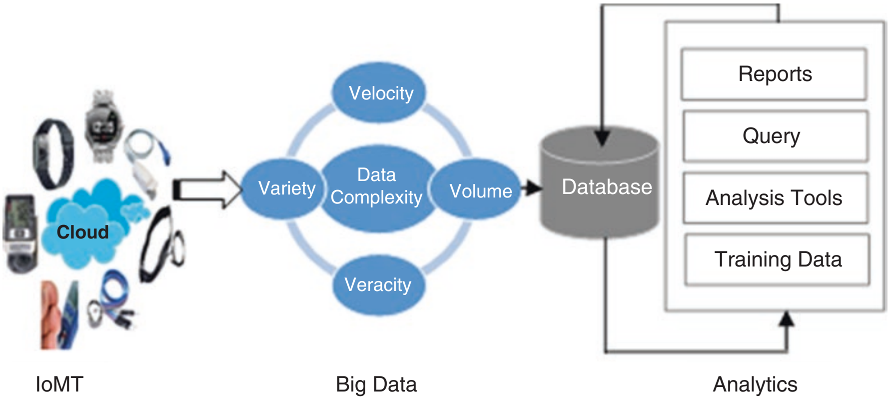

Fig. 8.3 The relationship between IoMT and big data

in various realms [46]. Typically, each data type is deemed only usable for its context, but cross-domain data have arisen as powerful resolutions to various glitches [47]. Different data types, for instance, runtime data, system metadata, business data, retail data, and corporate data, can today be employed because of the numerous supporting technology that supports IoMT, including Big Data, Cloud, Semantic Web, and Data Storage.

Value-added applications: Deep learning [48], machine learning [49], and artificial intelligence are key innovations that offer value-added IoMT and big data applications. Before IoMT and cloud computing emerged, large volumes of data and processing resources remain inaccessible for many applications and hence prohibit them from employing such machinery. Various data analytics solutions [50], business intelligence systems [51], simulation frameworks [52], and analytics apps [53] have recently appeared. They have helped companies and enterprises change their processes, improve their profitability and diagnostics, and incrust them. This amount of specificity had not been available until IoMT appeared.

Decision-making: The explosion of IoMT-based apps, mobile phones, and social networks presents decision-makers with an ability to collect useful knowledge about their customers, forecast potential patterns, and identify fraud. By rendering knowledge accessible and available to enterprises, big data will create tremendous value, thus allowing them to reveal uncertainty and improve their performance. Considerable data engendered through IoMT and numerous analytical gadgets produce a wide range of healthcare system changes. These methods use statistical analysis, grouping, and clustering approaches to deliver diverse approaches to data mining [54–57]. Mining IoMT will also use big data to improve people's decision-making behaviors.

Big data analytics provides well-designed tools to analyze Big Data in IoMT in real time, generating accurate decision-making outcomes. Big data analytics focused on IoMT demonstrates complexity, growing scale, and capabilities of real-time data processing. Big data fusion with IoMT is introducing new possibilities for creating a smart healthcare environment. Big data analytics focused on IoMT has wide-ranging implementations in almost every industry. The key performance areas of healthcare analytics, however, are reduction in hospital backlog admissions, rating healthcare network, the accuracy of forecast and test tests, enhanced decision-making, efficiency, decreased risk assessment, and improved patient segmentation.

8.5 Framework for the Cloud and IoMT-Based Big Data Analytics System

The IoMT paradigm principle has many interpretations focused on the abstraction and description of IoMT domains [45]. It provides a reference model that distinguishes associations between different IoMT verticals [45]. The big data analytics architecture provides a data abstraction approach. The Cloud and IoMT-based architecture offer recognition for various sensors and devices, while the big data analytics provides an interpretation of the data gathered from these connected devices. Many current architectures provide a prototype that builds on the standard. For instance, [58], in a cloud-centric IoT environment, provided an IoT architecture with cloud computing at the core and a model of endwise engagement between different stakeholders.

However, for a closer comparison with the existing Cloud and IoMT-based big data analytics platform is an advantageous IoT–based big data analytics system focusing on IoT in communications [45]. The proposed framework is accomplished by seamless universal sensing, data processing, and information representation with MIoT as the unifying while also concentrating on interactions with MIoT. There has been no research in the recent literature on the proposed program to our knowledge that combines MIoT and big data analytics.

Figure 8.4 demonstrates the Cloud and IoMT-based big data analytics system. The framework comprises of perception layer with numerous radar gadgets and items which can be linked over a radio receiver link. This radio receiver link could be separate from Wi-Fi, ultra-wideband, RFID, ZigBee, and Bluetooth. The IoMT gateway tolerates the cyberspace and numerous networks to connect. The upper level is about big data analytics, where vast volumes of data obtained from radars are processed in the cloud and accessible by big data analytics apps. These frameworks provide API monitoring and a dashboard to aid in managing engine communication.

There are three layers in the proposed framework, namely, the first layer is called the perception, the second is the integrated Cloud and IoMT-based and big data analytics, and the third is the application layer. Figure 8.4 displays a thorough explanation of every layer, and its execution scenario is conversed.

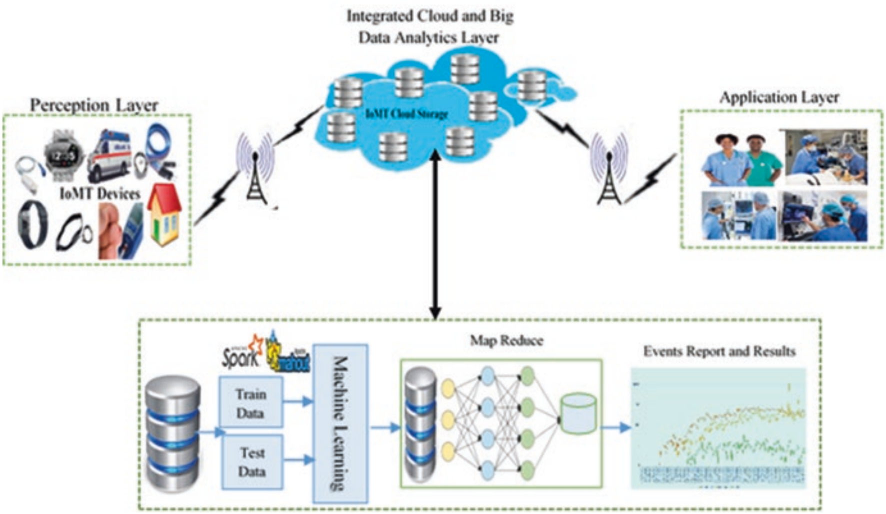

Fig. 8.4 The framework for COVID-19 pandemic using Cloud and IoMT-based and big data analytics

8.5.1 Perception Layer

The first layer was used to collect patient's information data from the built-in wearable sensor such as body temperature and heartbeat rate can be obtained by attaching it to the patient body. These sensors can also be positioned on the right wrist, left ankle, and chest to perceive and investigate the undertaking by innumerable parts of the body, posture sensing, and body position. For instance, the ePatch sensors placed on the chest is used to archive and tracks the ECG with physical efforts of a person. The obtained data from these wearable sensors are transferred and can be linked over a radio receiver link. This radio receiver link could be separate from Wi-Fi, ultra-wideband, RFID, ZigBee, and Bluetooth.

8.5.2 Integrated Cloud and IoMT-Based and Data Analytics Layer

The second layer collects the recorded and physical activities data from different IoMT devices and wearable sensors attached to the body of any person. The collected data will transmit through, and of Wi-Fi, ultra-wideband, RFID, ZigBee, and Bluetooth and the network gateways to the cloud platforms such as Amazon Web Service (AWS) or Cloud Google medium, where it is stored for real time of future analyzed at the big data analytics processor. The daily activities recorded can be processed and analyzed by select and extract features from multiple wearable sensors that are transferred to the HDFS big data processor and Cloudera virtual machine [59, 60]. Hadoop MapReduce can be used to execute the enormous amount of input data since it can process multiple cores in parallel.

Seventy percent to thirty percent of the input data is divided into rations, where 70% of the data is used for preparation purposes, and the remaining 30% of the information is used for research purposes and to estimate the physical movements of the data gathered under observation. Machine learning algorithms such as support vector machine, artificial neural network, deep learning, among others, can be used for the implementation of obtained data from these IoMT devices and wearable sensors using Mahout. The physical activities of the recorded actions over time can be calculated utilizing machine learning techniques. The attained outcomes from the big data processor after examination are communicated wirelessly to the application layer.

8.5.3 The Application Layer

The application layer is divided into data visualization and user interfaces. Data visualization techniques are divided into remote expert interface and monitoring interface, which are used to generate reports and sent to end-user interfaces.

Remote Expert Interface
The inaccessible experts use the interface to manage any allocated patients by generating results and documentations from the examination of the classifiers built on day-to-day events. Decisions are made, centered on patient data, body temperature, heartbeat diagnosis, and classification outcomes. In the case of emergencies such as high body temperature, high blood glucose falls detection and heart attacks, during the monitoring of a person during COVID-19 outbreak, warning notifications are sent to caregivers for more therapy advice to stratify hazards and initiate essential achievement strategies.

Monitoring Interface
The caregivers will be able to monitor the behavior of their close and precious ones in this interface. For instance, the patient is at risk or the heart rate is below 40 if the body temperature is too high >1800 °C, then all actions are null. The patient is at stake; in the event of an emergency, a warning notice via text message will be sent to the caregivers. These three layers are incredibly integrated and interoperable and move data effectively from wearable devices to sensors, gateways, server, storage, retrieval, research, and users.

The security of any IoT-based devices is very significant, thereby for efficient security requirements was considered in designing the system, such as security are access control, trust and privacy data authenticity and data should be regarded as in remote monitoring of the patient to combat COVID-19 pandemic. The DICOM and HIPPA international standard was also considered when the layers communication of clinical data and information and nonclinical [61].

8.6 The Practical Implementation Scenario of the Proposed Framework

The conceptual architecture consists of five main components of advanced technology: Big data processing software, cloud servers, IoMT gateway, network apps, and IoMT systems and sensors. Since IoMT devices and sensors produce an immense volume of data (Big Data), which is after that forwarded to a TCP (Transmission Control Protocol) port where an analytics platform is previously in succession and heeding to this channel. The tool mediator is set up with the actual data streams created by IoMT as the origin and the Apache as the sink so that after listening from the TCP port, the data are stored on Apache tools. The proposed analytics solutions are simplified (i.e., the big data analytics platform uses all of the Apache environment's virtual machines) to store the data. The IoMT-based instruments and monitors are single or multiple practical IoMT instruments such as blood pressure monitors, glucose sensors, temperature sensors, oxygen sensors, luminosity sensors, smoke/hazardous gas detectors, and others. Cloud storage is typically used to store the enormous amount of data produced by IoMT devices and sensors before submitting it to the computing software used by big data analytics.

The network tools are used to connect via any wireless network accessible among other components. The IoMT sensor data collection, optimization, and simulation can be conducted in the big data analytics software and even the building environment is managed based on the effects of the real-time data analysis. As mentioned previously, the data produced from the virtual sensors are ingested into the tools used by Apache. The data are processed in real time from the Apache application and will be saved in the cloud database for future use depending on the findings of the analytics.

For tracking purposes, the smartphone applications are empowered with IoMT-based devices providing real-time information using wireless network gateways, Wi-Fi network, RFID, etc. They have been used in different ways that are extensively useful to intensify the chance of monitoring and detecting infected people [7, 62]. The implementation of smartphone applications with IoMT-based platforms during COVID-19 outbreak might have the benefits of having a complete cloud database with COVID-19 outbreak data and information which government, physicians, and healthcare experts can use to monitor and allow the infected person receiving treatment from home. It is possible for the people to upload their health-related information to the cloud using an IoMT-based cloud database and get health advice from physicians' online without being physically present at the clinic. Treatment is being administered within this platform, and without expanding the contamination, the patient will be cured at home. The system is cost-effective when compared with the existing methods with direct contact and appointment with physicians, and the report can be used by the government to make better decisions and action in future pandemics. They will be able to manage the outbreak effectively [63].

The application of wearable smart glasses in IoMT-based devices has also proved useful in detecting the COVID-19 outbreak among people. This can also be replaced with thermometer guns with its characteristic of less human interaction. The smart glass empowered with thermal camera and with the functionality of optical imaging have been used to monitor people in a crowd [64]. The face recognition technology within the sensor captures the user's body temperature, and tracking of an infected person becomes more comfortable. The data from smart glasses become more reliable with the help of Google Location History, which can be used to track the infected patient contact within a given time. The report of the captured data can be handy from the IoMT-cloud database or sent to the physicians' smartphone for further actions [64]. For example, a Chinese company Rokid designed smart glasses with infrared devices to fight the COVID-19 outbreak and this can monitor up to 200 people [65]. The combination of Vuzix intelligent glasses with Onsight Cube camera thermal is another excellent example of these devices; in detecting high temperature the device is very helpful and provide a real-time report for medical centers.

Different IoMT smart thermometers that can be used to record constant measurement of body temperatures have been developed. They are created in various types such as radiometer, touch and patch; they are accurate devices and cost-effective [66]. The tools are beneficial in early diagnosis, treatment, and monitoring of COVID-19 patients and any suspicious cases that can arise from the outbreak. Also, infrared thermometers can spread the COVID-19 outbreak when used for taking body temperature because of the nearness of the infected person and the physician; thus, smart thermometers will be of help in such cases [67]. Different wearable thermometers can be used during this period such as IFiever, Isense, Ran's Night, Tempdrop, among others, which report the body temperature in real time on smartphones and can be used as sensors on IoMT-based devices. These touchable devices can be a stick or worn on the skin under clothing [66]. For example, In the USA, Kinsa's thermometers have been used to predict the most suspicious areas based on the recorded reports using temperature measurement to detect the highest of being infected with the COVID-19 virus [68–70]. This thereby helps the system to diagnose new COVID-19 patients without stress and increase people's daily lives.

Another acceptable sensor is the smart helmet with a thermal camera when compared with the infrared thermometer gun due to its lower human interactions [71]. The image and location of the user's face are taken when an optical camera detects the high temperature on the smart helmet and report it to the IoMT-cloud database. Experts can differentiate the infected person, and take necessary action immediately. The use of the devices allows physicians and other related officers have access in the crowd to personal information, dark spot visioning temperature, and facial recognition of the user.

The smart helmet has the storage capacity to keep all of the captured data within the helmet, and thus serve as a backup for the IoMT-cloud database [71]. Moreover, the smart helmet integrated Google Location, and the history of the infected person can be used to find the places after discovery [72]. This wearable device has been used successfully in countries such as Italy, the United Arab Emirates (UAE), and China to monitor crowds within two meters and has shown promising results [73, 74]. For instance, a Chinese company produced a smart helmet called KC N901 used for body temperature discovery with an accuracy of 96% and has been used by the countries as mentioned earlier [73–75].

Based on the specifications of popular therapeutic organizations and the physiognomies of entirely all forms of disease community, by offering primary diagnostic services for targeted remote health identification, experts can get the technical diagnostic facility at all periods and appropriately access their well-being information. At the same time, it is possible to monitor the development of all types of growing acute, chronic sickness inmates. Bettering care, antecedent detection, antecedent intervention, and early recovery will advance the value of the life of people with severe illness and decrease the risk of sickness. A delayed diagnosis will significantly reduce federal health benefits, revolving to prevent crucial disease.

Sustainable healthcare based on the IoMT-based sensor. Since IoMT-based system incorporates several physiological sensors into the body of patients, it could collect a range of critical physical markers and has the benefits of being relaxed, appropriate for the aging, progenies, and persons with physical and psychological sickness. Hence, utilizing these innovative wearable devices will create a modern medical infrastructure that incorporates less-power radio receiver networking, cloud computing, big data, and deep learning technologies to comprehend customized healthcare services based on simple physiological knowledge tracking. The core therapeutic services are primarily focused on a handful of huge sanitoria. IoMT-based expertise offers a way to exchange different sections of current medical services and is one of the critical steps for ensuring parity of health. Cloud and IoMT-based systems satisfy the demand of consumers in a timely way, consider the patient's current state of health, enhance contact between physicians and sick persons, and reduce the waiting period for therapeutic care, which will boost client loyalty and at the same time maximize hospital performance. Right telemedicine may achieve a standardized norm. Apart from smart healthcare, this theoretical system could be applied to other uses. Smart agriculture, intelligent vehicles, smart cities, and aircraft may be used to track and regulate sensors and equipment rates to ensure convenience, health, and protection.

8.7 Conclusion

The integration of computer and biomedical technologies in medical systems has supported healthcare events, for instance, real-time disease analysis, remote monitoring of patients, and real-time drug prescriptions, among others. The methods have significantly helped to store both patients' personal information and their symptoms on the cloud, which can help during the COVID-19 pandemic. This aids the quality of services provided by the physicians, thereby improve patients' satisfaction. IoMT and wearable sensors and devices can aid early diagnosis of COVID-19 pandemic and create ease of detection during response to the outbreak. These devices have a remarkable impact on the prompt detection of the COVID-19 outbreak. For instance, cloud and IoMT-wearable sensors have the capacity to show any part of them that is not functioning well when they are used to capture patient health status and thereby create big data. With the results from these devices, users can notice any change in their health condition frequently and book an appointment with a physician before it is generated to real disease or any symptoms appear. The implementation of cloud-IoMT-based wearable sensors will make the fight against COVID-19 pandemic easier and effective. Also, monitoring COVID-19 patients remotely would be more convenient and reduce the number of patients admitted into hospital or isolation centers.

In this chapter, the core principles of Cloud and IoMT-based big data analytics pieces of machinery in the medical sector were explored in depth. This chapter addressed the big data analytics focusing on IoMT, the possibilities, expectations, and threats in the healthcare sectors. We also proposed a Cloud and IoMT-driven integrated data analytics platform for the healthcare industry, focusing on a broad software application structure built on medical IoMT and big data applications. This chapter as well demonstrates the architecture of the extensive healthcare system based on IoMT, the technological problems, and some standard implementations relevant to comprehensive healthcare. Data safety and confidentiality will be looked at for future research with Cloud and IoMT-based big data analytics with healthcare systems. Machine learning approaches to solve the problem related to changing sensory inputs should be integrated. Developing countries, particularly African hospitals, should be thinking about how IoMT can be deployed in hospitals to reduce costs as it is feasible and economical. Government, medical, and research collaboration is relevant to improving IoMT implementation and deployment at our hospital. This chapter concluded that current big data analytics approaches based on IoMT were still in their initial development periods. Therefore, immediate analytics resolution that could offer speedy understanding would be necessary and helpful.

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